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Liquid jet target system for laser-plasma interactions at kHz repetition rate

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We present our recent development of a compact liquid target setup and a proof-of-principle demonstration of laser-driven ion acceleration and X-ray emission at 1 kHz repetition rate.

The target system is based on a high-pressure chromatography pump, which introduces a continuous flow of liquid into the vacuum chamber through a capillary, forming a microjet. After passing the laser-target interaction point in vacuum, the remaining liquid is collected by a specially designed catcher system, equipped with a temperature control to prevent freezing and drain water out of the chamber for recycling. In combination with a liquid nitrogen cold trap, it allows to perform experiments at high vacuum. Supplied with deionized water, the developed target is debris-free and demonstrates precise dimensional and positional tolerance.

For plasma production we used a commercial laser capable of producing ultrashort pulses (~45 fs FWHM) of ~6 mJ at 1 kHz repetition rate. With a high-quality OAP the intensity on target reached 10^{17} W/cm^2. The accelerated ion beam was characterized in terms of energy distribution and shot-to-shot stability by time-of-flight solid-state diamond and SiC detectors, demonstrating the cut-off energy up to 170 keV. The X-ray spectrum of the interaction was acquired by a silicon-drift detector in the range from 2 to 40 keV. Overall, the demonstrated target performance at 1 kHz makes it a promising candidate for applications in the fields of laser-driven nuclear physics and material science, e.g. proton-boron fusion research and X-ray fluorescence spectroscopy.